【学位論文審査の要旨】

This thesis is the basic study on storm runoff analysis by the different existing storage function models as well as the newly proposed ones. These storage function models were applied in different Japanese catchments to examine their effectiveness using hydrograph reproducibility and the information criteria point of view, and to evaluate their uncertainty.

Accurate prediction of flood hydrograph is important for the flood mitigation to avoid the losses due to flood plain inundation in both rural and urban areas. For this purpose, among the different rainfall-runoff models, storage function (SF) models have been widely used in many parts of the world, especially in Japan. The selection of an appropriate SF model for the intended purpose is very important due to the existence of a variety of SF models. Hence, there is a need for the comparative studies of SF models to evaluate their ability to predict discharge and to provide guidelines for end-users. However, the predictions made using rainfall-runoff models are inherently uncertain and it is necessary to carry out parameter uncertainty analysis of a calibrated model because it is one of the major sources of uncertainty. Further, there is a need for a generalized SF (GSF) model that can be applied in all the watersheds by incorporating all the possible inflow and outflow components and the rainfall spatial variability since it has not been considered in the SF models so far.

Based on the aforementioned background, this thesis first established an effective SF model from the existing ones in terms of hydrograph reproducibility and Akaike information criterion (AIC) perspective. Further, parameter uncertainty of the effective SF model was evaluated by the bootstrap and jackknife resampling techniques. Finally, this thesis proposed a GSF modelfor the water level prediction by considering the spatial rainfall distribution. for the water level prediction by considering the spatial rainfall distribution.

The main outcomes of this thesis are summarized as follows:

(1) The relatively new urban storage function (USF) model was compared with the four conventional SF models to evaluate its effectiveness in an urban watershed. The USF model revealed higher hydrograph reproducibility among the SF models in terms of high values of Nash-Sutcliffe efficiency (NSE) coupled with the lower values of root mean square error (RMSE) and other error functions. Furthermore, the USF model received the lowest AIC score and the highest Akaike Weight (AW) during most of the flood events, which indicates that it is the most parsimonious model compared to other SF models.

(2) Parameter uncertainty of USF model, which was identified as the effective model,

was evaluated using the bootstrap and jackknife resampling approaches. Both the approaches were applied to the residual time series that was computed as the difference between the observed and calibrated discharge. The parameters from the highest to the lowest uncertainties were derived by utilizing two newly proposed parameter uncertainty indices. The highly uncertain parameters obtained were the same by the bootstrap and jackknife approaches even though the order of other model parameters was different. Moreover, the effect of parameter uncertainty on model simulations was also investigated.

(3) The spatial distribution of rainfall over the urban watershed was considered in the USF model by introducing a parameter named as rainfall distribution factor (γ). The model performance was evaluated based on hydrograph reproducibility, AIC, and AW. The results revealed that the USF model with parameter γ performed well in the considered urban watershed which further emphasized the effect of parameter γ in USF model.

(4) A 9-parameter GSF model was proposed for the water level prediction from the rating curve relationship and considering the parameter γ. The proposed GSF model was then applied to the semi-urban and rural watersheds in Japan along with three other SF models to examine its applicability in different types of watersheds. The GSF model exhibited higher water level hydrograph reproducibility as well as lower AIC values compared to the other SF models in both the considered watersheds.

In brief, this thesis examined the effectiveness of different existing SF models and proposed a new GSF model to overcome the shortcomings of the existing SF models. The thesis thus made a notable contribution to the field of storm runoff analysis and surface water hydrology. Therefore, this thesis is acknowledged to hold a highly satisfactory content for conferring the Doctor of Philosophy in Engineering.